

# A new epigean species of *Trichopeltis* Pocock, 1894 from southwest China (Diplopoda, Polydesmida, Cryptodesmidae)

Zhenfei Wu<sup>1</sup>, Sihang Zhang<sup>1</sup>, Fuxue Qin<sup>2</sup>, Peiyun Cong<sup>1</sup>

1 Yunnan Key Laboratory for Palaeobiology & MEC International Joint Laboratory for Palaeobiology and Palaeoenvironment, Institute of Palaeontology, Yunnan University, Kunming 650500, China

2 Earthquake Prevention and Disaster Reduction Bureau of Zhaoyang, Zhaotong 657099, China

Corresponding author: Sihang Zhang (eva@ynu.edu.cn)

## Abstract

A new species of Cryptodesmidae, *Trichopeltis jiyue* sp. nov., is described from the Ailaoshan National Nature Reserve in Yunnan Province, southwest China. The new species is distinguished from its congeners by the gonopodal coxae with two conspicuous wing-like processes, the relatively long, stout setae on the gonopodal coxae, gonopodal telopodites glabrous and four-branched, and the acropodite curved caudolaterad. The new species is the second record of an epigean species of genus *Trichopeltis* Pocock, 1894 in China. An updated key is provided to all 14 presently known species.

**Key words:** Key, millipedes, taxonomy, Yunnan



Academic editor: Pavel Stoev

Received: 22 May 2024

Accepted: 9 September 2024

Published: 18 October 2024

ZooBank: <https://zoobank.org/9FAD26B7-8734-4CFC-94A6-66211BECF33F>

Citation: Wu Z, Zhang S, Qin F, Cong P (2024) A new epigean species of *Trichopeltis* Pocock, 1894 from southwest China (Diplopoda, Polydesmida, Cryptodesmidae). ZooKeys 1216: 17–26. <https://doi.org/10.3897/zookeys.1216.128080>

Copyright: © Zhenfei Wu et al.

This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0).

## Introduction

The Polydesmida is one of the most diverse orders of Diplopoda (millipedes), containing about 5000 species in 30 families (Brewer et al. 2012) and with many species globally widespread (Shelley 2003). All Polydesmida are blind and eyeless, and metaterga usually show small to prominent lateral paranota or paraterga (Brewer and Bond 2013).

The Cryptodesmidae Karsch, 1880 is a relatively small family of Polydesmida comprising approximately 40 genera and 130 species (Golovatch et al. 2010; Liu et al. 2017). It occupies three geographic areas: Neotropical (Mexico to Argentina), Afrotropical (continental sub-Saharan Africa), and Asian + Australasian (Central Asia and the Himalayas to Japan and Papua New Guinea) (Golovatch and Vanden-Spiegel 2017). In tropical or subtropical Asia and Australasia, 12 genera and 36 species have been documented in Cryptodesmidae (Liu et al. 2017). The diagnosis of Cryptodesmidae has been revised by Enghoff et al. (2015) as follows: body incapable of volvation, strongly flattened; collum strongly enlarged, flabellate, with radiating lines; paraterga strongly developed, broad and subhorizontal; pore formula normal, but deviating; ozopores absent, or present on small tubercles, removed from lateral edge of paraterga; metaterga without cerotegument, densely setose and/or uniformly tuberculate, arranged in numerous transverse rows; limbus microcrenulate; epiproct exposed, from rather simple and subconical to strongly flattened

and deeply incised at lateral edges; legs without sphaerotrichomes; and gonopods without seminal chamber, often with a hairy pulvillus (Enghoff et al. 2015).

*Trichopeltis* Pocock, 1894 is one of the tropical or subtropical genera of Asian Cryptodesmidae. Currently, this genus encompasses 13 species, mainly documented in Indonesia, Myanmar, Laos, Vietnam, Cambodia, southern China, and the Himalayas (Golovatch 2015, 2016; Golovatch and VandenSpiegel 2017; Likhitrakarn et al. 2017; Liu et al. 2017; Liu and Wynne 2019). This genus is well defined and characterized by a tripartite or deeply notched gonopod telopodite, including a small middle to caudal solenomere branch (Golovatch et al. 2010). Six species of this genus have been reported from China, including five cavernicolous and one epigean species.

In this paper, we describe a new epigean species of *Trichopeltis* from southwest China and update the key to all known species in this genus. This new species represents the second record of an epigean species of *Trichopeltis* in China.

## Materials and methods

All specimens were collected from the Ailaoshan National Nature Reserve (24°32'N, 101°01'E, 2476 m above mean sea level) in Yunnan Province, southwest China. Yunnan Province is well known for its high biodiversity (Yang et al. 2004). Ailaoshan Mountain National Nature Reserve stretches across six counties, or cities, of Yunnan, and is mainly covered with mid-montane humid evergreen broad-leaved forest with abundant wild fauna and flora resources (Qiu et al. 1998). The subtropical evergreen broadleaved forest is old-growth (>300 years) and well protected (Yang et al. 2007). All collected millipedes are preserved in 75% ethanol. The holotype and paratypes are deposited in Yunnan University, China.

The live photographs were taken in the habitats of the described species using a SONY DSC-RX1R camera. All specimens were further studied and photographed with a Nikon SMZ25 stereomicroscope and Nikon DS-Ri2 microscope camera within the laboratory. Scanning electron microscope (SEM) images were taken with a FEI Quanta FEG 650 with gold coating. All figures are prepared with Affinity Photo v. 2 and Affinity Designer v. 2. The terminology used here follows that of Golovatch and VandenSpiegel (2017).

## Results

### Taxonomy

**Order Polydesmida Leach, 1815**

**Family Cryptodesmidae Karsch, 1880**

**Genus *Trichopeltis* Pocock, 1894**

***Trichopeltis jiyue* sp. nov.**

<https://zoobank.org/77367C20-B420-457F-A095-AB493A6BB2F7>

**Type material. Holotype:** • ♂ (YNU-MD 0151), China, Yunnan Province, Pu'er City, Jingdong Yi Autonomous County, 24°54'78"N, 101°03'58"E, 2450 m elev., 4.X.2021, leg. Peiyun Cong, Sihang Zhang, Zhenfei Wu & Fuxue Qin. **Paratypes:** • 4 ♂, 9 ♀ (YNU-MD 0152-165) same location as the holotype.

**Etymology.** Jiyue (Chinese spelling) alludes to the bright white appearance when the animal emerges from the leaf mold, like the moon appearing from behind a dark rain cloud.

**Diagnosis.** *Trichopeltis* is characterized by the relatively long and stout setae on the gonopodal coxae, with the posterior part having two conspicuous wing-like processes (cxp); gonopodal telopodites glabrous and four-branched; and the acropodite curved caudolaterad. The living animal is uniformly bright white.

**Description.** Length of ♂ ca 17.2–17.8 mm, paratype ♀ ca 17.0–17.4 mm, width of midbody pro- and metazonae 2.2–2.4 mm and 5.3–5.4 mm (♂), 2.2–2.5 mm and 5.1–5.4 mm (♀), respectively.

**Coloration** of tergites uniformly bright white (Fig. 1A); fed 1–2 months with local mor and leaves, yellow (Fig. 1B); in alcohol, after months of preservation, whitish-yellow to yellow (Fig. 1C, D). Antenna whitish-yellow (proximal) to reddish-purple (distal).

**Adults body** with 20 segments, collum plus 17 podous and 1 apodous tergites, plus 1 telson. In width, head << collum < segment 2 < 3 < 4 < 5 < 6 < 7–17, thereafter body tapered towards telson.

**Head** sparsely pilose, epicranial suture present (Fig. 2A). Antennae short and clavate, reaching tergite 4 when stretched ventrally; in length, antennomere 6 > 3 > 2 = 4 > 5 > 1 > 7 (Fig. 2A); antennomeres 5–7 each with a bacilliform sensilla field apico-laterally, the numbers of bacilliform sensilla are 100, 67, and 34, respectively.

**Collum** completely covering the head from above, inverted subtrapeziform, regularly convex at peripheric margin, caudal margin slightly concave (Fig. 2B); arranged with 12 or 13 regular, transverse rows of small, spherical, setigerous tubercles on the surface, tubercles 8–13+8–13 per row, surrounded with spherical granulations, seta on each tubercle directed caudad (Fig. 2B).

**Prozona** of segments following collum finely shagreened, metazona densely tuberculate and setose; fore and caudolateral margins of collum, anterolateral, lateral and caudal margins of following paraterga of segments besides telson with obvious dentiform-lobulate lobules, smallest at mid-dorsal region and slightly larger bidirectionally at caudal margins of paraterga.

**Dorsum** convex, postcollum paraterga flat, very broad and long, narrowly rounded laterally, axial line absent. Metatergal segments 2–16 with four or five irregular transverse rows of similarly small, spherical, setigerous tubercles. Tubercles decreasingly extend to paraterga, but each of the latter only with three or four irregular rows of similar tubercles (Fig. 2C), surrounded by spherical granulations, same to collum; following metatergal segments 17 and 18 with 6–8 rows of smaller tubercles.

**Paraterga** very strongly developed (Fig. 2C), regularly declivous, the tips extending down below level of venter (Fig. 2D). Segments 2–15 slightly projecting forward, each with 6–9 small, crown-like dentiform, lateral lobules (Fig. 2I) and 7–9 tongue-shaped to squarish caudolateral lobules; all evident, setigerous and microvilloso segments 16–19 projecting caudally, each with 5–7 small, crown-like dentiform, lateral lobules and 9–13 tongue-shaped to squarish, caudolateral lobules; all evident, setigerous, and microvilloso.

**Sterna** sparsely setose; axial line present; tergite stricture divided into pro- and metazone parts. Limbus, with a row of tongue-shaped lobules, microdenticulate apically (Fig. 2G). Pore visible, lying on the ventral paraterga of segment 5, ozopores formula not discernable.

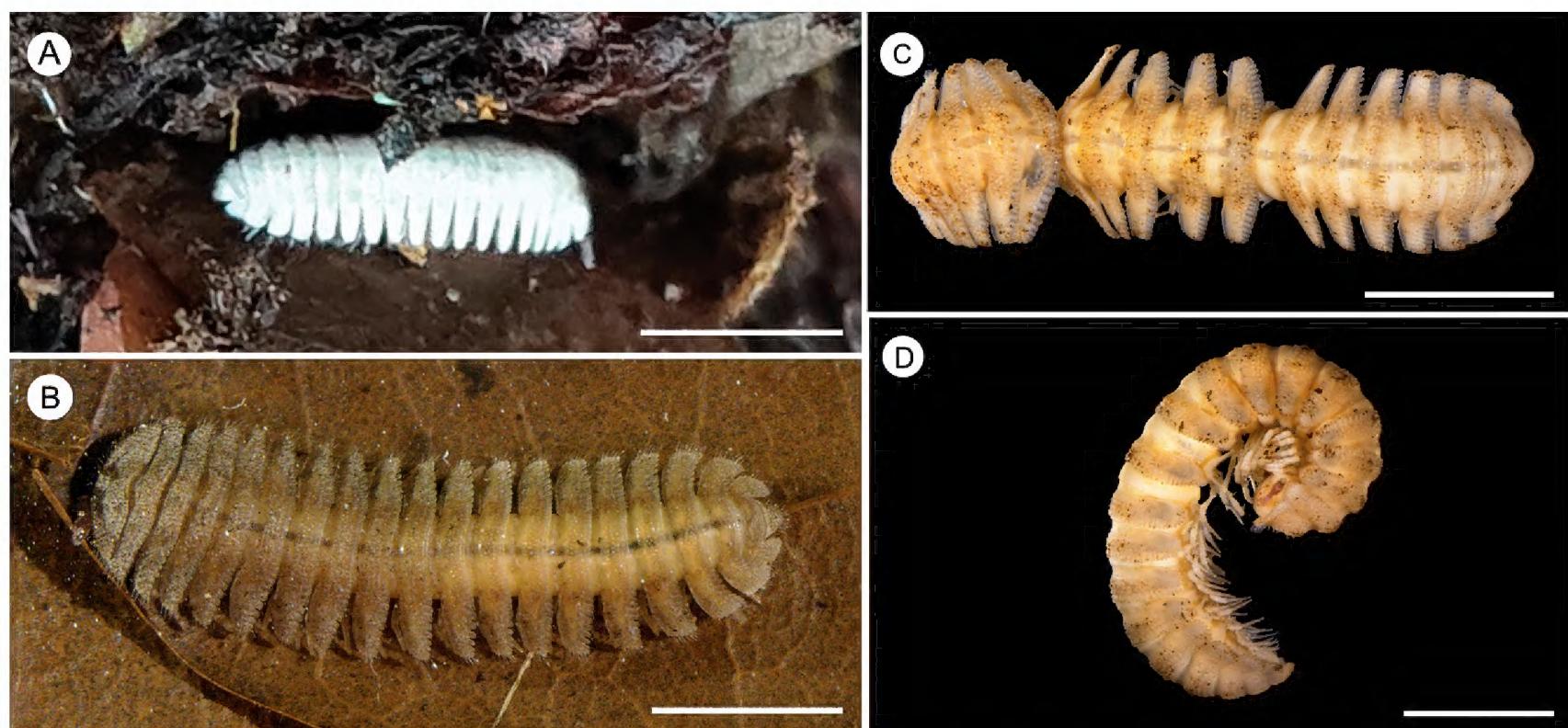


Figure 1. External morphology and colouration of *Trichopeltis jiyue* sp. nov. **A** ♂ holotype in habitus and live **B** fed 1–2 months in laboratory **C, D** ♀ paratype, after 3 months storage in 75% alcohol. Scale bars: 10 mm (A); 5 mm (B–D).

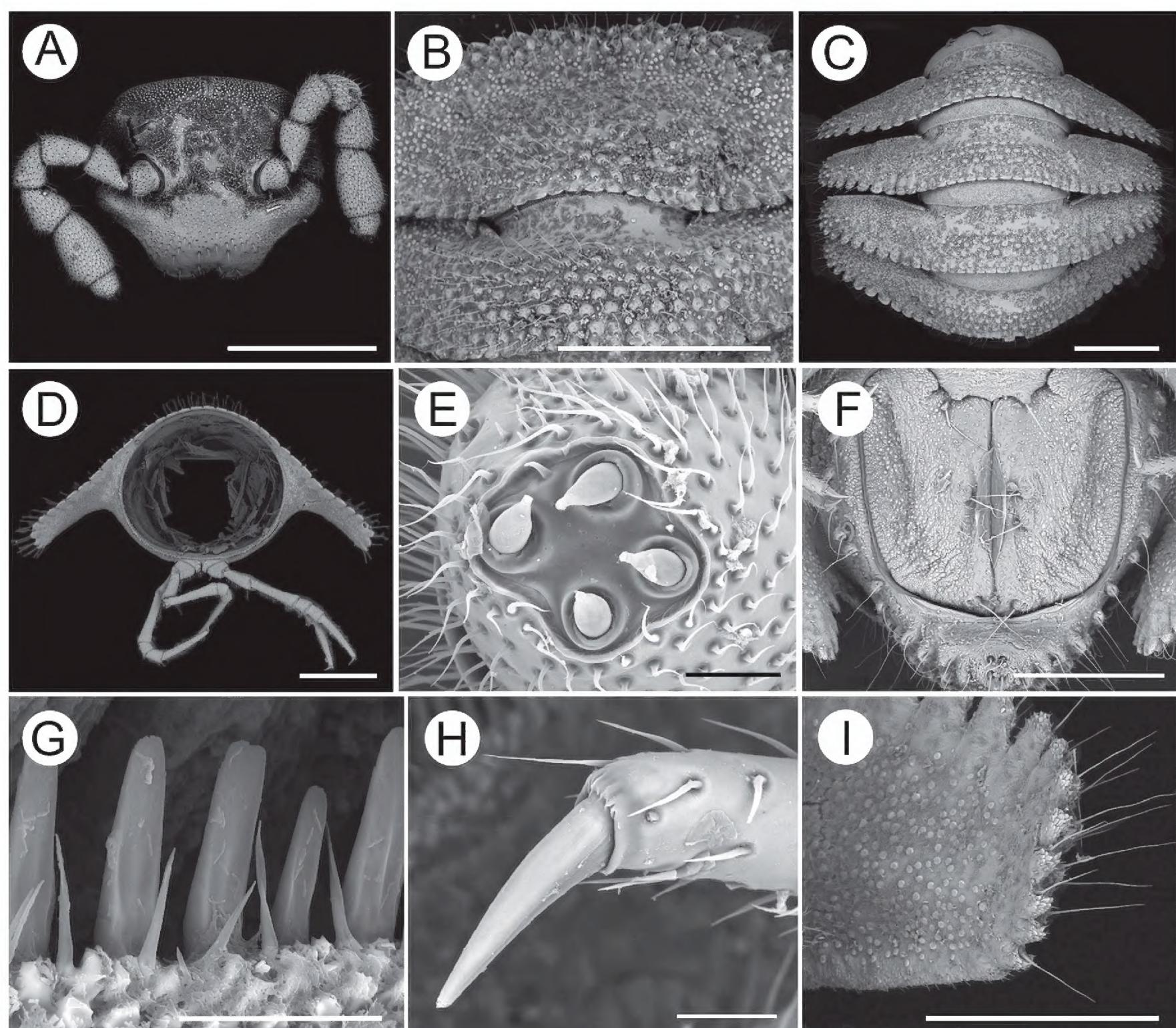


Figure 2. SEM images of *Trichopeltis jiyue* sp. nov., ♂ holotype **A** head, dorsal view **B** collar and the second segment, dorsal view **C** segments 6–9, dorsal view **D** cross-section of segment 5, caudal view **E** antenna disc coeloconic sensilla, plan view **F** telson and anal, ventral view **G** limbus of segment 5, subventral view **H** claw of leg, subventral view **I** paraterga of segment 6, ventral view. Scale bars: 1 mm (A–D); 50 µm (E, H); 20 µm (G); 500 µm (F, I).

**Telson** (Fig. 2F) conical, with numerous spherical granulations; epiproct flattened dorsoventrally, microtuberculate, with four strong apical papillae. Hypoproct roundly subtrapeziform, 1+1 caudal setae separated, surface rugged.

**Legs** (Fig. 2D, H) long and slender, without modifications, longer than paraterga when stretched straight, about 1.2 times as long as the width of paraterga. In length, femur ≈ tarsus >> prefemur > coxa = tibia > postfemur > claw.

**Gonopods** complex (Figs 3, 4). Coxae with relatively long stout setae; with two conspicuous wing-like processes (cxp). Telopodite complex, with four-branched process (**p**), clearly curved (Figs 3, 4), approximately as long as coxa, divided by a notch (Fig. 3D); prefemur glabrous; femorite (**p1**) one leaf-shaped lobe on the inner side mesally; branch **p2** leaf-shaped, three times as long as **p1**, rather thick, curved caudolaterally, with dense micro-setae on surface, distal margin with serrate process; **p3** subconical, with three apical processes; **p4** leaf-shaped, close to the **p2**, the distal margin consists of numerous conical processes, forming a corolliform pulvillus; with no distinct solenomere.

**Remarks.** The specimens were found on a stoney roadside, which some researchers usually walk around. As compared with virgin forests, the surroundings were relatively densely populated. However, the environment is undeveloped, and it the new species seemed abundant.

### Key to species of *Trichopeltis*

Modified after Liu et al. 2017.

- 1 Tegument unpigmented, pallid to light yellowish; cavernicolous species.2
- Tegument clearly pigmented, bright white, red- or grey-brown to blackish; epigean species.....7
- 2 Central parts of metaterga with 2–4 irregular, transverse rows of setigerous tubercles; gonopodal coxite as usual, at most with only few setae ...3
- Central parts of metaterga with 5–6 irregular transverse rows of setigerous tubercles; gonopodal coxite unusually densely setose on lateral side; Yunnan, China .....6
- 3 Paraterga declivous; tergal setae very long, about half as long as body diameter; gonopodal telopodite clearly twisted. Guizhou, China.....  
..... ***T. latellai* Golovatch et al., 2010**
- Paraterga clearly upturned; tergal setae much shorter; gonopodal telopodite untwisted .....4
- 4 Gonopodal telopodite with a hairy pulvillus; coxite short and squarish, without seta; central parts of metaterga with 4 irregular, transverse rows of setigerous tubercles. Guangxi, China .....  
..... ***T. liangfengdong* Liu & Wynne, 2019**
- Gonopodal telopodite without pulvillus .....5
- 5 Central parts of metaterga with 2–3 subregular, transverse rows of setigerous tubercles; acropodite strongly condensed, tripartite.....  
..... ***T. reflexus* Liu, Golovatch & Tian, 2017**
- Central parts of metaterga with 3–4 irregular transverse rows of setigerous tubercles; Telopodite only slightly curved caudad, vaguely tripartite. Laos..... ***T. cavernicola* Golovatch, 2016**

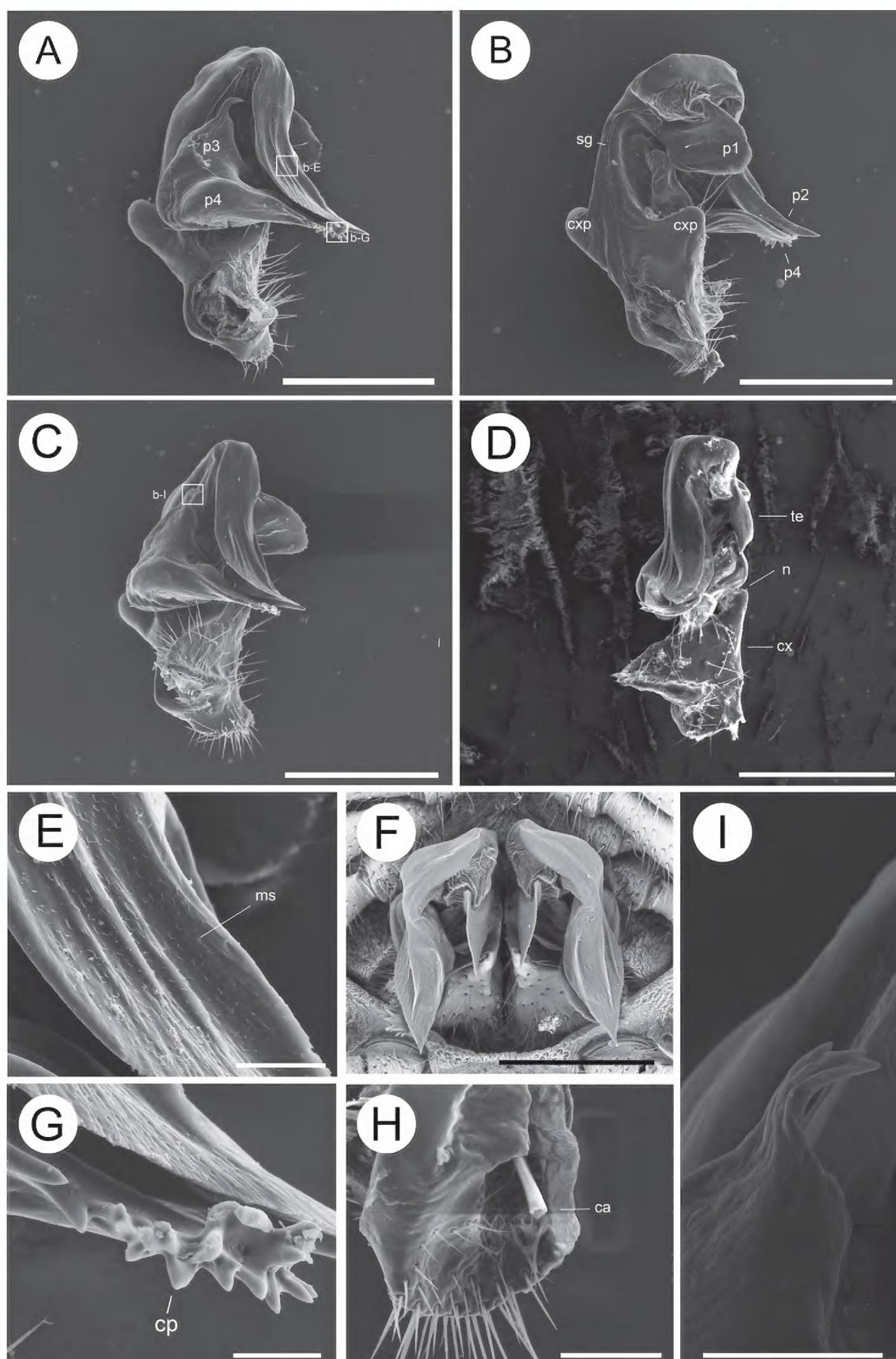
- 6 Tergal setae long; gonopods relatively simple ..... *T. bellus* Liu, Golovatch & Tian, 2017
- Tergal setae short; gonopods rather complex ..... 12
- 7 Central parts of metaterga with 4–6 irregular, transverse rows of setigerous tubercles ..... 8
- Central parts of metaterga with 2–3 irregular, transverse rows of setigerous tubercles ..... 11
- 8 Gonopodal telopodite with evident branches ..... 13
- Gonopodal telopodite without long branches ..... 9
- 9 Central parts of metaterga with 4–5 subregular, transverse rows of setigerous tubercles; gonopodal telopodite with a conspicuous accessory seminal chamber and a pulvillus but devoid of denticles laterally or mesally. Laos ..... *T. muratovi* Golovatch & VandenSpiegel, 2017
- Central parts of metaterga with 5–6 subregular, transverse rows of setigerous tubercles; gonopodal telopodite without accessory seminal chamber but with a pulvillus, also abundantly denticulate either laterally or mesally ..... 10
- 10 Gonopodal telopodite abundantly denticulate on lateral face. Vietnam, Laos, and Cambodia and possibly endemic to the Indochina Peninsula .... ..... *T. kometis* Attems, 1938
- Gonopodal telopodite abundantly denticulate on mesal face. Sumatra, Indonesia ..... *T. bicolor* Pocock, 1894
- 11 Frontal margin of paraterga abundantly lobulated. Solenomere lobe-shaped, tip nearly pointed ..... *T. feae* Pocock, 1895
- Frontal margin of paraterga entire, not lobulated. Solenomere axe-shaped, tip pointed ..... *T. watsoni* Pocock, 1895
- 12 Each coxa with a conspicuous, high, curved, laterally densely setose process ..... *T. sutchariti* Likhitrakarn et al., 2017
- Each coxa with a small process without setae ..... *T. intricatus* Liu, Golovatch & Tian, 2017
- 13 Clearly 3-branched; solenomere long and slender ..... *T. doriae* Pocock, 1895
- Clearly 4-branched; with two conspicuous wing-like process (wp) basal, one pan-shaped lobe on the inner side; acropodite reverse caudally against femorite, unfolded into sheet form. Yunnan, China ..... *T. jiyue* sp. nov.

## Comparisons

The Cryptodesmidae comprises about 40 genera. The new species can be assigned to the genus *Trichopeltis* Pocock, 1894 based on the lobulated and tuberculate-setose tergites, subcordiform gonopod aperture, four-branched telopodite, and coxa divided by a notch.

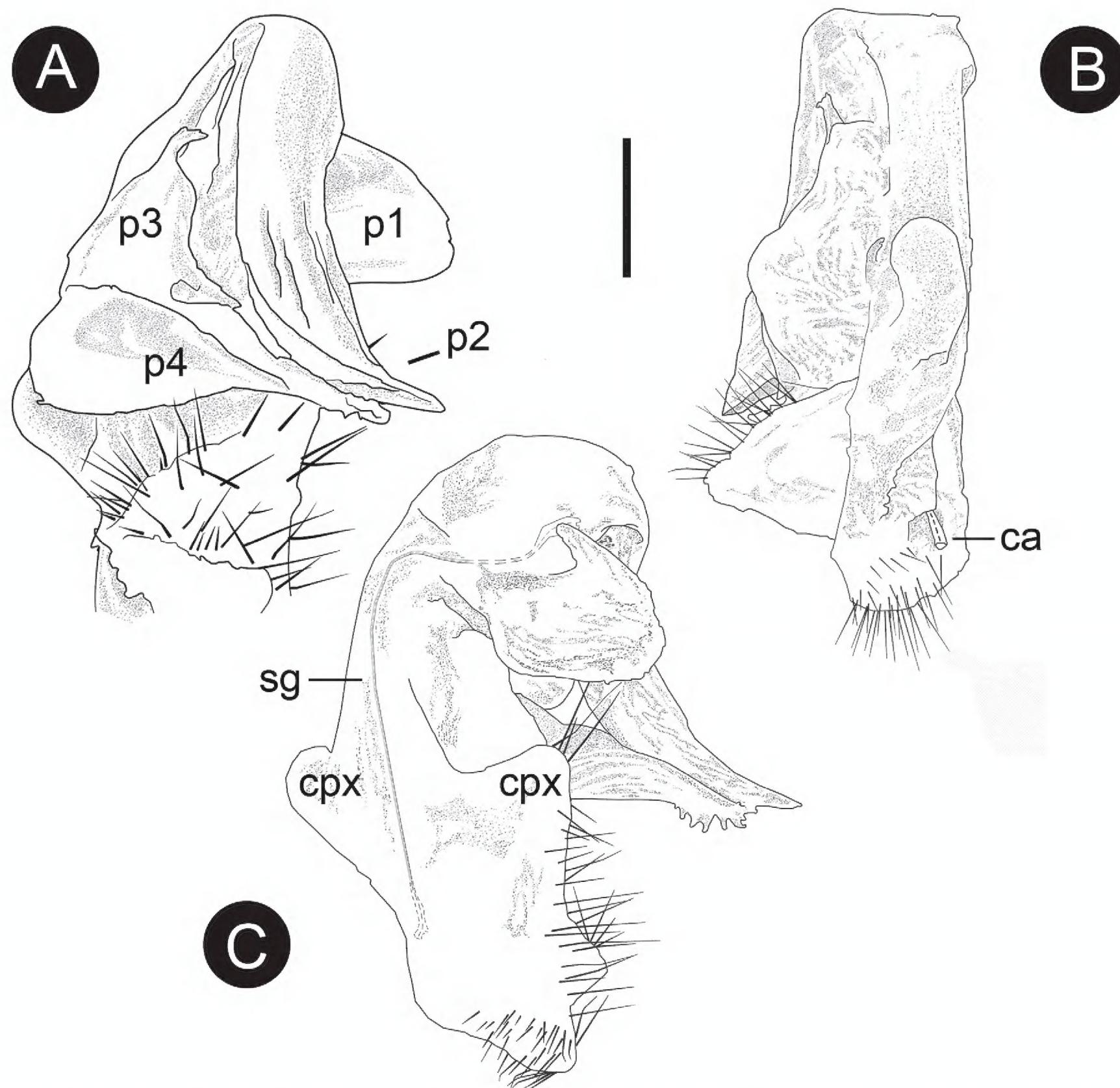
Amongst all known 14 species of *Trichopeltis*, *T. jiyue* sp. nov. is most similar to *T. kometis* Attems, 1938 (Golovatch & Akkari, 2016), *T. doriae* Pocock, 1895, *T. intricatus* Liu, Golovatch & Tian, 2017, *T. sutchariti* Likhitrakarn et al., 2017, and *T. muratovi* Golovatch & Vanden Spiegel, 2017.

The gonopodal telopodite of *T. jiyue* sp. nov. clearly differs from that of *T. doriae* in having four branches, in contrast to the gonopodal telopodite of *T. doriae* which bears three branches; also, it differs from *T. muratovi* in the telopodite, which has a conspicuous accessory seminal chamber, in contrast to the



**Figure 3.** Gonopodal characters of *Trichopeltis jiyue* sp. nov., ♂ holotype, paratype. **A, C** right gonopod, sublateral and subfrontal views **B** left gonopod, subcaudal view **D** right gonopod, ventral view, coxite and telopodite divided by a notch **E** enlargement of box-E of A, prefemur sheet micro-setose on the surface **F** gonopod, ventral view from above **G** enlargement of box-G of A, corolliform solenomere **H** seminal groove **I** box-I of C, tripartite apical process. Abbreviations: p1, p2, p3, p4 = processes of telopodite; cp = corolliform pulvillus; cxp = coxa process; ms = microsetae; sg = seminal groove; tap = tripartite apical process; ca = cannula; cx = coxa; te = telopodite; n = notch. Scale bars: 500 µm (A–D, F); 50 µm (E, G); 100 µm (H, I).

gonopodal telopodite of *T. jiyue* sp. nov., which is without a conspicuous accessory seminal chamber; furthermore, the gonopodal surface of the new species is relatively smooth, with dense microsetae, and differs from that of the abundantly denticulate gonopodal surface of *T. kometis* and *T. bicolor* Pocock, 1894.



**Figure 4.** *Trichopeltis jiyue* sp. nov., ♂ holotype, paratype. **A** subfrontal view **B** subcaudal view **C** caudal view. Abbreviations: p1, p2, p3, p4 = processes of telopodite; cpx = coxa process; sg = seminal groove; ca = cannula. Scale bar: 200 µm.

*Trichopeltis intricatus* and *T. sutchariti* were also found in Yunnan Province, China. Compared to *T. jiyue* sp. nov., the body size of *T. jiyue* sp. nov. is much larger; the length of the adult is over 17 mm, the pro- and metazonae are over 2 and 5 mm long, respectively, which is much longer than *T. intricatus*. *T. intricatus* is relatively short, ca 10 mm long, with the width of midbody pro- and metazonae 1.5 and 2.5 mm, respectively. Furthermore, the tuberculations on the collum have up to 12 or 13 irregular, transverse rows, which is more differ than the eight to nine irregular, transverse rows of *T. sutchariti*. The characters of the gonopod reveal many obvious interspecific differences.

### Conclusions

*Trichopeltis jiyue* sp. nov. is described from Ailaoshan National Nature Reserve in Yunnan Province, southwest China. It represents the second record of an epigean species of the genus *Trichopeltis* in China. An updated identification key (modified from Liu et al. 2017) to all known species of *Trichopeltis* is provided here.

## Acknowledgements

We thank Canchen Liao and Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences for providing us scientific research field. We appreciate the valuable comments and useful suggestions on our manuscript from the associate editor and the reviewers. Last but not least, we extend our deep gratitude to Professors Sergei Golovatch, Natdanai Likhitrakarn, and Pavel Stoev for invaluable constructive feedback, and to Dr. Christopher Glasby and Dr. Robert Forsyth for polishing and revising the English of the manuscript.

## Additional information

### Conflict of interest

The authors have declared that no competing interests exist.

### Ethical statement

No ethical statement was reported.

### Funding

This work is supported by the Yunling Scholar funding and a joint grant of YNU-Yunnan Government (202201BF070001-016).

### Author contributions

Data curation: FQ. Writing - original draft: ZW. Writing - review and editing: SZ, PC.

### Author ORCIDs

Zhenfei Wu  <https://orcid.org/0009-0004-5586-6511>

Sihang Zhang  <https://orcid.org/0000-0002-8230-6892>

Fuxue Qin  <https://orcid.org/0009-0001-1140-3927>

Peiyun Cong  <https://orcid.org/0000-0001-9910-6478>

### Data availability

All of the data that support the findings of this study are available in the main text.

## References

Brewer MS, Bond JE (2013) Ordinal-level phylogenomics of the arthropod class Diplopoda (millipedes) based on an analysis of 221 nuclear protein-coding loci generated using next-generation sequence analyses. *PLoS ONE* 8(11): e79935. <https://doi.org/10.1371/journal.pone.0079935>

Brewer MS, Sierwald P, Bond JE (2012) Millipede taxonomy after 250 years: classification and taxonomic practices in a mega-diverse yet understudied arthropod group. *PLoS ONE* 7(5): e37240. <https://doi.org/10.1371/journal.pone.0037240>

Enghoff H, Golovatch SI, Short M, Stoev P, Wesener T (2015) Diplopoda—taxonomic overview. *Treatise on Zoology-Anatomy, Taxonomy, Biology. The Myriapoda*, Vol. 2, Koninklijke Brill NV, Leiden, The Netherlands, 363–453. [https://doi.org/10.1163/9789004188273\\_017](https://doi.org/10.1163/9789004188273_017)

Golovatch SI (2015) Review of the millipede genus *Ophydesmus* Cook, 1896, with the description of a new species from southern Vietnam (Diplopoda: Polydesmida:

Cryptodesmidae). Tropical Natural History 15(2): 155–165. <https://li01.tci-thaijo.org/index.php/tnh/article/view/103079>

Golovatch SI (2016) The millipede family Cryptodesmidae in Indochina (Diplopoda: Polydesmida). ZooKeys 578: 33–43. <https://doi.org/10.3897/zookeys.578.7994>

Golovatch SI, Akkari N (2016) Identity of the millipede, *Pseudonipponiella kometis* (Attems, 1938) (Diplopoda: Polydesmida: Cryptodesmidae). Tropical Natural History 16(1): 1–6. <https://li01.tci-thaijo.org/index.php/tnh/article/view/103069>

Golovatch SI, VandenSpiegel D (2017) One new and two little-known species of the millipede family Cryptodesmidae from Indochina (Diplopoda, Polydesmida). Zoologicheskii zhurnal 96(7): 757–767. <http://doi.org/10.7868/S0044513417070066>

Golovatch S, Geoffroy JJ, Mauriés JP, Vandenspiegel D (2010) Two new species of the millipede genus *Trichopeltis* Pocock, 1894 (Diplopoda: Polydesmida: Cryptodesmidae) from Vietnam and China. Arthropoda Selecta 19(2): 63–72. <https://doi.org/10.15298/arthsel.19.2.01>

Likhitrakarn N, Golovatch SI, Srisonchai R, Panha S (2017) A new species of *Trichopeltis* Pocock, 1894 from southern China, with a checklist and a distribution map of *Trichopeltis* species (Diplopoda, Polydesmida, Cryptodesmidae). ZooKeys 725: 123–137. <https://doi.org/10.3897/zookeys.725.22014>

Liu W, Wynne JJ (2019) Cave millipede diversity with the description of six new species from Guangxi, China. Subterranean Biology 30: 57–94. <https://doi.org/10.3897/subtbiol.30.35559>

Liu WX, Golovatch SI, Tian M (2017). Three new cavernicolous species of the millipede genus *Trichopeltis* Pocock, 1894 from southern China (Diplopoda, Polydesmida, Cryptodesmidae). ZooKeys 710: 1–14. <https://doi.org/10.3897/zookeys.710.20025>

Qiu XZ, Xie SC, Liu WY (1998). Studies on the forest ecosystem in Ailao Mountains, Yunnan, China. Yunnan Sciences and Technology Press, Kunming.

Shelley RM (2003) A new polydesmid millipede genus and two new species from Oregon and Washington, USA, with a review of *Bidentogon* Buckett and Gardner, 1968, and a summary of the family in western North America (Polydesmida: Polydesmidae). Zootaxa 296(1): 1–12. <https://doi.org/10.11646/zootaxa.296.1.1>

Yang Y, Tian K, Hao J, Pei S, Yang Y (2004) Biodiversity and biodiversity conservation in Yunnan, China. Biodiversity & Conservation 13: 813–826. <https://doi.org/10.1023/b:b-loc.0000011728.46362.3c>

Yang LP, Liu WY, Yang GP, Ma WZ, Li DW (2007) Composition and carbon storage of woody debris in moist evergreen broad-leaved forest and its secondary forests in Ailao Mountains of Yunnan Province. Chinese Journal of Applied Ecology 18(10): 2153–2159.